Spatial and Environmental Risk Factors for Diarrheal Disease in Matlab, Bangladesh

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Abstract

The objective of this research project is to assess risk for diarrheal disease in rural Bangladesh by analyzing the complex and dynamic interaction of biological, socioeconomic, cultural/behavioral, and environmental factors over time and space. Risk factors of cholera and non-cholera watery diarrheal disease are calculated to compare the relative importance of risk for several independent variables. Diarrheal disease data were collected for people who were hospitalized at the International Centre for Diarrhoeal Disease Research (ICDDR) hospital (Matlab, Bangladesh) from January 1, 1992, to December 31, 1994. Using laboratory and hospital records, cases were assigned to one of two diarrhea disease categories (cholera or non-cholera watery diarrhea) that were used as dependent variables in the analysis stage of the research. Age-matched individuals were randomly chosen from the community to be controls. Information was collected for independent variables that were hypothesized to be related to watery diarrhea. This information was collected by administering questionnaires, obtaining secondary data from the ICDDR's demographic surveillance system records and community health worker record books, and calculating variables using a geographic information system database. Sanitation and water availability and use are extremely important in the effort to reduce secondary transmission of cholera and non-cholera watery diarrhea. Water use and availability variables were more important for non-cholera watery diarrheal risk than for cholera, but they were important for both. Socioeconomic status is an important indirect cause of both of these diseases because poverty is the root cause of many of the other variables, such as lack of sanitation and clean water. Flood control was related to both types of diarrhea, but it is not understood why. Because the Bangladesh Flood Action Plan maintains and will continue to build flood-control embankments, it is important to investigate whether there is a pattern to this relationship throughout the country and to investigate why the relationship exists.

Keywords: diarrheal disease, cholera, Bangladesh, medical geography

Introduction

Diarrheal diseases cause one-third of the 15 million annual deaths in children under five years old in the developing world (1) and they are the largest cause of death among children under five in Bangladesh (2,3). The people of Bangladesh suffer not only directly, when they contract the disease, but also indirectly, from economic hardship due to lost productivity and medical expenses. Because of resource constraints in developing countries like Bangladesh, it is necessary to identify risk factors so preventative

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health programs can focus on particular interventions. Assessing risk for diarrheal disease requires knowledge of the complex and dynamic interaction of biological, socioeconomic, behavioral, cultural, and environmental factors over time and space. The objective of this study is to advance such knowledge in the context of rural Bangladesh.

Humans were the only known reservoir of *Vibrio cholerae* until the mid-1980s, when theories of the ecology of cholera were substantially revised. During this time, Colwell et al. (4) published the results of a study claiming that vibrios can live freely in an aquatic environment, even under conditions of nutrient deprivation, if the environment is not sodium-free. Prior to this study, it was maintained that cholera was only transmitted by ingestion of feces-contaminated food or water. However, Colwell's research suggests that transmission can occur through water without fecal contamination. If transmission can occur without fecal contamination, then these findings dramatically change long-standing conceptions of the ecology of cholera.

This study differentiates between two types of diarrhea: cholera and non-cholera. Cholera watery diarrhea is defined as watery diarrhea caused by the bacterium *Vibrio cholerae.* Non-cholera watery diarrhea is defined as watery diarrhea caused by microorganisms other than *Vibrio cholerae.* Ideally, this study would have distinguished between all of the non-cholera diarrheal agents; however, the microbiological tests associated with obtaining this information would have been exorbitantly expensive. This study differentiates between risk factors for cholera and non-cholera diarrhea.

The research was conducted at the International Centre for Diarrhoeal Disease Research (ICDDR). The ICDDR has a field station called Matlab, where the Centre's diarrhea treatment hospital is located. It is in south central Bangladesh, approximately 50 kilometers southeast of Dhaka, adjacent to where the Ganges River meets the Meghna River forming the Lower Meghna River. Figure 1 shows the study location within Bangladesh relative to Dhaka City, three major South Asian rivers, and the Bay of Bengal.

Conceptual Framework

Analyzing risk of contracting watery diarrheal disease in Bangladesh requires a conceptual framework that addresses the complexities of biological, socioeconomic, cultural/behavioral, and environmental factors over time and space. A medical geographic theoretical approach that addresses these issues is disease ecology, which maintains that disease results from a dynamic complex of variables that coincide in time and space (5–15). Hunter (16) argues that researchers must not take a pathogen-centric view of disease, that is, one that focuses only on the disease agent. He suggests that studies of disease "must co-jointly involve pathogen, host, and environment" (16). He views "environment" broadly, as consisting of "diverse physical, biological, social, cultural, and economic components" (16). Hunter defines geography as a discipline that bridges the social and environmental sciences and writes that "its integration and coherence derive from systems-related analysis of man-environmental interactions through time and over space" (16).

This paper is intended to demonstrate the value of a medical geographic approach that is holistic and that integrates many different types of variables responsible for disease. The types of variables to be investigated have been classified in many different ways, but Mayer's classification system (17) is most useful. Mayer differentiates

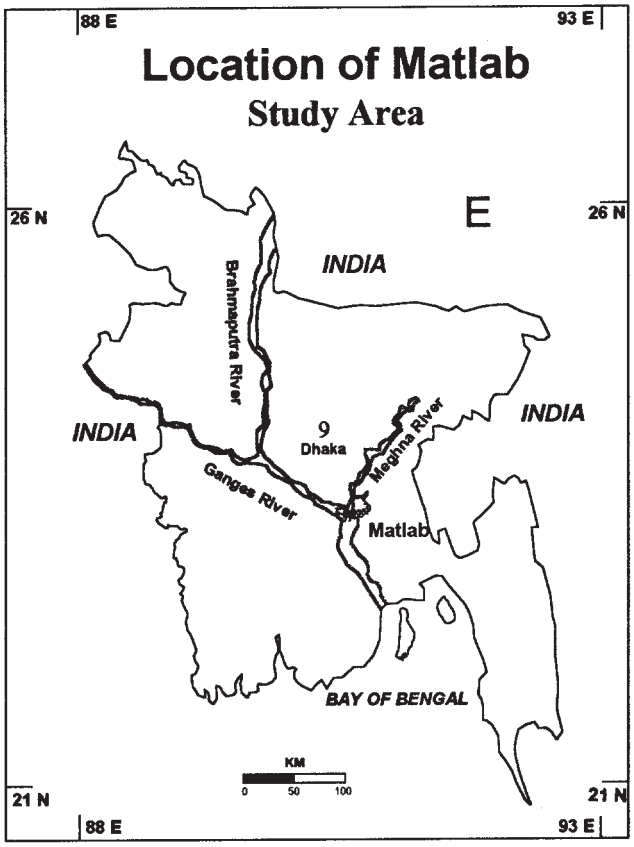

Figure 1 Location of diarrhea treatment center, Matlab, Bangladesh.

between biological, socioeconomic, behavioral, and environmental variables. Biological variables are those that describe biological characteristics of the host, such as blood type. Behavioral variables are those that describe individual or group behaviors, and may be related to culture or individual decision-making (for example, what types of food people eat). Environmental variables are those of the biophysical environment, such as climatic variables. Socioeconomic variables are variables that affect the coincidence of agent and host, such as wealth or class. Different patterns of socioeconomic, behavioral, and environmental variables result in different spatial and temporal patterns of disease. Virtually every disease exhibits spatial and temporal variation, and medical geographers attempt to explain this variation.

Research Design

The author created a vector geographic information system (GIS) database of the Matlab field research area. Features in digital format include baris, rivers, roads, and a flood-regulating embankment. Baris are patrilineally related clusters of households. Figure 2 shows three features in the GIS database: the flood-regulating embankment,

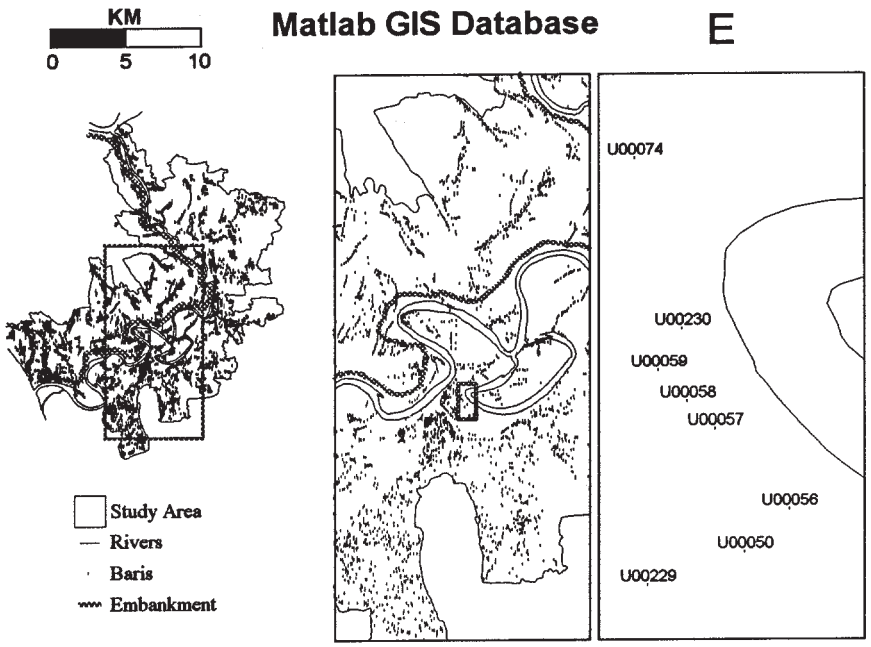

Figure 2 Study area of GIS database.

the Dhonagoda River, and baris. The three map views in Figure 2 are displayed at different scales. The map view on the far right has the individual bari identification numbers visible. The baris are all identified by an ICDDR demographic surveillance system (DSS) census number within the structure of the GIS database. This allows attribute data to be linked to the spatial database. Thus, disease incidence data can be linked to specific bari locations.

The Matlab field research center is a diarrhea treatment center (DTC) that has in- and outpatient services, a laboratory for the identification of pathogens, and research facilities. The DTC laboratory consists of microbiology, clinical pathology, and biochemistry units, which provide diagnostic services to the hospital and for field research activities. There are motorized boats that function as a free ambulance service for diarrhea patients, so access to the hospital is remarkably good. All DTC services are free as well. The research center maintains a community-based data collection system. One hundred twenty community health workers (CHWs) visit each household every two weeks to collect demographic, morbidity, and other data. The DSS conducts periodic censuses (most recently in 1993) and uses CHWs to update demographic data (births, deaths, and migrations).

Diarrheal disease data were collected for people from the Matlab treatment area who were hospitalized at the diarrhea treatment center with watery diarrhea between January 1, 1992, and December 31, 1994. The cases were assigned to one of two diarrhea disease categories (cholera or non-cholera watery diarrhea) that were used as dependent variables in the analysis stage of the research. For each patient admitted to the

Matlab DTC, a stool sample was regularly collected and routinely tested for *Vibrio cholerae* and *Shigella*, a dysenteric agent. In this study, laboratory records of the patients were used to assign one of the two above agent categories. Hospital records specify whether there was blood in each patient's stool. Patients who tested positive for *Shigella* or who had blood in their stool were excluded because this study is not concerned with dysentery. Patients who did not have dysentery or cholera were assigned to the non-cholera watery diarrhea category. For each patient with cholera or non-cholera watery diarrhea, the bari identification number was collected for mapping.

Individuals were randomly chosen from the community to be controls. After the cases were identified, a list of potential controls was compiled from DSS records. A person was eligible to be a control if she/he lived in the Matlab surveillance area, was not admitted to the DTC during the study period, and did not die of a diarrheal disease during the study period. The controls were age-matched. For cases of diarrhea in persons older than five years of age, controls were chosen who were born in the same year. For those less than five years old, controls were chosen who were born in the same month. Children under five had a stricter age-matching interval because there were more potential controls who were in this age group. In addition, calculating certain biological independent variables for children required a smaller age-matching interval because the status of these variables was collected on a monthly basis.

Information was collected for independent variables that were hypothesized to be related to watery diarrhea. This information was collected by administering questionnaires, obtaining secondary data from DSS records and community health worker record books, and calculating variables using the GIS database. These data were collected for both cases and controls. Tables 1, 2, and 3 summarize the different variables that were collected.

Results

Cholera

Two of the environmental independent variables—living in a household that shared its latrine with other households and living in a flood-control area—were strongly associated with cholera hospitalization. Participants whose households shared latrines with other households had a 2.8 times greater chance of being hospitalized with cholera. Sharing latrines represents increased exposure to the fecal material of others, which can lead to secondary transmission. Individuals living in flood-controlled areas were 2.47 times more likely to be hospitalized with cholera. It is not entirely clear why this is true. One theory is that flood control exacerbates cholera bloom by some unknown mechanism (18). Flood control may change salinity levels or may impede the natural flushing out of cholera-laden water. The association between cholera and flood control may, however, be entirely unrelated to flood control. There may be another variable that is associated with flood control, creating a spurious association between flood control and cholera hospitalization. In the future, cholera incidence rates in other flood-controlled areas of Bangladesh should be compared with rates in their surrounding areas. Similarities of the environments of these flood-controlled areas should be identified so that, if cholera incidence is higher in these areas, a causal pathway can be determined. The multi-billion dollar Bangladesh Flood Action Plan may or may not be responsible

Table 1 Summary of Categorical Independent Variables with Two Classes

Variable	Variable Type	Description
Gender	Cultural/behavioral and biological	Male or female
Source of drinking water	Cultural/behavioral	Tubewell or other
Source of cooking water	Cultural/behavioral	Tubewell or other
Source of bathing water	Cultural/behavioral	Tubewell or other
Source of washing water	Cultural/behavioral	Tubewell or other
Working tubewell in bari	Environmental	Yes or no
Adult male defecation	Cultural/behavioral	Latrine or other
Adult female defecation	Cultural/behavioral	Latrine or other
Male child defecation	Cultural/behavioral	Latrine or other
Female child defecation	Cultural/behavioral	Latrine or other
Presence of latrine in household	Environmental	Yes or no
Type of latrine drainage	Environmental	Septic or not
Number of households using a latrine	Environmental	Single or multiple
Consumption of shellfish	Cultural/behavioral	Yes or no
Flood-controlled area	Environmental	Yes or no
Breastfeeding status of children under 5	Biological	Yes or no
Nutritional status of children under 5	Biological	Malnourished or not

Table 2 Summary of Categorical Independent Variables with More Than Two Classes

Variable	Variable Type	Description
Years of education: adult (over 15) participant	Socioeconomic	More than six; one to six; none
Years of education: mother	Socioeconomic	More than six; one to six; none
Years of education: father	Socioeconomic	More than six; one to six; none
Knowledge of prevention of diarrhea	Cultural/behavioral	Full; good; partial; none
Knowledge of source of diarrhea	Cultural/behavioral	Good; partial; none
Household construction material	Socioeconomic	Brick,/tin; bamboo/tin; jute/tin; straw/stick/bamboo

for increased cholera rates. Thus, it is important to investigate whether or not flood control is contributing to transmission of this disease.

Several of the cultural/behavioral variables that describe the water and sanitation situation of study participants did not reveal associations. Use of tubewell[1] water for drinking, cooking, bathing, or washing was not related to cholera hospitalization. This certainly does not mean that people do not need to use tubewell water to avoid contracting cholera. Almost all of the questionnaire respondents (95%) said that they regularly use tubewell water for drinking, so there is not a major problem with drinking water use. Defecation in places other than a latrine, households without latrines, and households with open latrines were not associated with cholera transmission. It is unclear why these variables (which represent an unsanitary environment) were not

[1] A tubewell is a drinking water well with a pump for extracting water from the shallow aquifer.

Table 3 Summary of Continuous Independent Variables

Variable	Variable Type	Description
Number of open latrines	Environmental	Count
Number of non-septic latrines	Environmental	Count
Number of ring septic latrines	Environmental	Count
Number of concrete septic latrines	Environmental	Count
Number of other households using latrines	Cultural/behavioral, environmental	Count
Latrines per person (excluding open)	Environmental	Latrines per 100 people
Number of tubewells in bari	Environmental	Count
Number of households sharing a common tubewell in bari	Cultural/behavioral, environmental	Count
Tubewells per person	Environmental	Tubewells per 100 people
Household area	Socioeconomic, environmental	Square feet
Bari population	Cultural/behavioral, environmental, socioeconomic	Count
Population density around baris	Cultural/behavioral, environmental, socioeconomic	Persons within half-kilometer radius
Total household assets	Socioeconomic	Taka
Annual income	Socioeconomic	Taka
Mid-arm circumference (children under 5 ears old)	Biological	Millimeters
Distance from main river	Environmental	Meters

associated with cholera, because they are no doubt responsible for secondary cholera transmission. There were also continuous variables associated with sanitation and water availability; these variables will be discussed below.

Another cultural/behavioral variable, shellfish consumption, was not associated with cholera transmission either. This is contrary to one of Colwell's (4) theories about an environmental reservoir for cholera. She believes that shellfish are one of the attachment sites for the bacteria. The lack of an association might be due to the fact that 92% of the people in the study population consume shellfish. The only people who might not consume any type of shellfish are extremely poor, and are thus more prone to contracting cholera because of other variable types (such as socioeconomic variables and variables involved with their access to and use of clean water and proper sanitation).

Two biological variables, breastfeeding and malnutrition, were not associated with cholera transmission. This may be attributed to the low number of child participants who were not breastfeeding during the month before hospitalization (23%) or who had a mid-arm circumference below 120 millimeters (12%).

The independent variables that had more than two ordinal classes included level of education for different household members, household construction material, and knowledge of diarrhea prevention and source. Education level and household construction material are socioeconomic variables that were hypothesized to show a negative association with cholera incidence; surprisingly, there were no associations. Knowledge about the source and prevention of diarrhea were hypothesized to be

inversely associated with cholera hospitalization, but there were no associations in that case either.

Modeling a complex problem such as what makes someone susceptible to contracting cholera requires that a variety of methods be used. Non-parametric statistics were used to measure associations between cholera and potential risk factors, and simple regression analysis was used for the continuous variables. The larger the number of open latrines in a bari, the more likely a resident was to contract cholera. Open latrines are basically fixed sites where people regularly defecate. These fixed sites are an indicator of an unsanitary environment. The number of households using tubewells was positively related to cholera hospitalization. It is unclear why this association exists but a speculation is offered. If many households share a tubewell, it may decrease access to that tubewell; thus, this relationship might indicate that access to tubewell water is important to preventing cholera.

Bari population and population density were positively related to cholera incidence. While it is not completely clear why bari population size is related to cholera hospitalization, one conjecture is that the larger the bari population, the larger the number of human contacts people have. The last variable that was related to cholera hospitalization was household area, a socioeconomic and environmental variable. (Household area is a socioeconomic indicator because people with smaller households are usually poorer, and it is environmental because smaller households represent a condition of crowding.) Household area was inversely related to hospitalization for cholera. There were two other socioeconomic indicators, assets and income, that were built into simple logistic regression models. However, neither was found to be related to hospitalization for cholera. Conroy (19) suggests that socioeconomic status in the developing world is a complex issue and that assets and income measure different parts of socioeconomic status. He states that income is an indicator of purchasing power and consumption, while assets are an indicator of a person's ability to develop options for improving their quality of life (e.g., participating in poverty alleviation programs). A house is part of a family's assets, although houses were not included in this study's original measurement of assets. Household area indicates how much a person is able to invest in their home, which is why the ICDDR collects this information regularly. While the variation of assets and income is quite small, there is a much larger variation in household area. The inverse relationship between household area and cholera shows that it is an important factor. The author believes that the environmental part of household area, which is a measure of crowding, and the socioeconomic part of this variable, which describes the socioeconomic status of a family, are inseparable yet both important. Crowding, however, is more likely to occur in poorer households. Poor people are at a major disadvantage in many other parts of their lives in rural Bangladesh. They are forced to eat cheaper food, which may be unsanitary. They may not be able to invest in proper water and sanitation facilities. Even if an outside organization is paying for the water and sanitation facilities, poorer people are less likely to have these facilities in their baris because they have less social power to influence how these resources are distributed. It is the belief of the author that poorer people are exposed to diseases at higher rates.

Because several different variables may interact in affecting risk of cholera hospitalization, a multiple logistic regression model was built using many independent variables. Because models were devised only for observations for which there were

data for all of the variables, the relationships do not refer to the same sample to which the simple regression models refer. Four of the variables that were significant in simple logistic regression models were also significant in the multiple logistic regression model. These were the number of open latrines in a bari, the household area, the bari population, and flood control.

Non-cholera

The risk factors for non-cholera watery diarrhea were somewhat different from the risk factors for cholera. Although some of the significant variables were the same as for cholera, the strengths of the associations were different. Four of the binary dependent variables were significantly associated with hospitalization for non-cholera watery diarrhea. Female participants were only 0.81 times as likely to be hospitalized with non-cholera watery diarrhea as males. In rural Bangladesh, males have more freedom of movement than females, so they are more likely to come into contact with a larger number of people. Contact with more people can lead to increased exposure to people infected with non-cholera watery diarrhea.

Participants who did not use tubewell water for drinking were 8.49 times more likely to be hospitalized with non-cholera watery diarrhea than were those who did use tubewell water. This extremely high association highlights the importance of clean drinking water for avoiding non-cholera watery diarrhea. There was also a relatively high association between not using tubewell water for bathing and hospitalization for non-cholera watery diarrhea. (Very few people actually bathe with tubewell water, and it is not a feasible public health option to change this. It would require a large educational effort to change the custom of bathing in rivers or ponds.) Individuals living in flood-controlled areas were 1.42 times more likely to be hospitalized with non-cholera watery diarrhea than individuals not living in flood-controlled areas. This was not as strong an association as with cholera, and, again, it is not entirely clear why there is an association. Future work must be conducted to ascertain the reason for this association and to investigate whether it exists in other flood-controlled areas of Bangladesh.

Several variables involving water availability and sanitation were not associated with non-cholera hospitalization. The absence of a working tubewell in a participant's bari did not lead to a greater hospitalization rate for non-cholera watery diarrhea. Defecation in places other than latrines was not associated with hospitalization, nor were participants who lived in households without latrines or who had latrines with open drainage systems more likely to be hospitalized with non-cholera watery diarrhea. Participants who shared latrines with other households did not have a greater chance of being hospitalized. The finding that these water and sanitation variables were not associated with watery diarrhea incidence does not mean that they are not important. The reason why so many water and sanitation variables were collected is that previous research has identified them as important. The strongest association of any water and sanitation variable for non-cholera watery diarrhea was the negative association found for using tubewell water as a drinking source. Thus, this portion of the issue of overall water and sanitation is most important.

Shellfish consumption, breastfeeding, and malnutrition were not associated with non-cholera watery diarrhea incidence, possibly because there was little variation in these variables. None of the ordinal-level variables (education for different household

members, household construction material, or knowledge of diarrhea prevention and source) was related to non-cholera watery diarrhea.

Simple regression analysis for continuous variables was also used to calculate risk of non-cholera watery diarrhea. Household area was inversely related to hospitalization for non-cholera watery diarrhea, as with hospitalization for cholera. Also as with cholera, assets and income—the two other socioeconomic indicators—were not related to non-cholera hospitalization. In accordance with the non-parametric test, people living in a flood-controlled area were more likely to be hospitalized with non-cholera watery diarrhea than were those not living in a flood-controlled area. There was one biological variable associated with non-cholera watery diarrhea that was not associated with cholera. Mid-arm circumference was related to non-cholera watery diarrhea hospitalization at the 95% confidence level. The ICDDR considers a mid-arm circumference of less than 120 millimeters to indicate malnutrition in children under five years old, in this study population. Stratifying this variable as above and below 120 revealed no association, but the raw data values show a relationship. There were only 37 observations for this variable, which may explain the absence of an association using the non-parametric test.

Three variables were significant in a multiple logistic regression model for non-cholera watery diarrhea using variables that were at least moderately significant in the simple regression models. The variables were household area, flood control, and tubewell density. Household area was negatively related to non-cholera hospitalization—the smaller the household, the more likely it was that an individual would be hospitalized. As with cholera, people living in flood-controlled areas were more likely to be hospitalized with non-cholera watery diarrhea. Tubewell density was highly significant when built into a multiple logistic regression model, but was only moderately significant in a simple regression model. This indicates that there was interaction with some other variable. As tubewell density increased, non-cholera watery diarrhea hospitalization decreased. This relationship highlights the importance of clean water availability as a protective barrier to non-cholera hospitalization.

Discussion

It becomes apparent on arrival in rural Bangladesh that people there are always in close contact with the aquatic environment. The aquatic environment is an important source of income for fishers and farmers and it provides the most important system of transportation for people living in the study area. Another readily apparent characteristic of the study area is that there are many people living in a small area and that all land seems to be used for some economic activity. By developing-world standards, it is also clear that almost everyone living in the study area is extremely poor. Figure 3 displays the factors that were found to be statistically significant in cholera transmission.

Only two variables that describe characteristics of water and sanitation infrastructure or use were related to cholera transmission. Secondary cholera transmission is by the fecal-oral route, and is thus due to the lack of clean water and good sanitation. (In fecal-oral transmission, people are infected when they ingest something that has been contaminated with fecal material.) Thus, it is no surprise that two water- and sanitation-related variables are associated with cholera.

Other variables related to cholera transmission describe the number of people

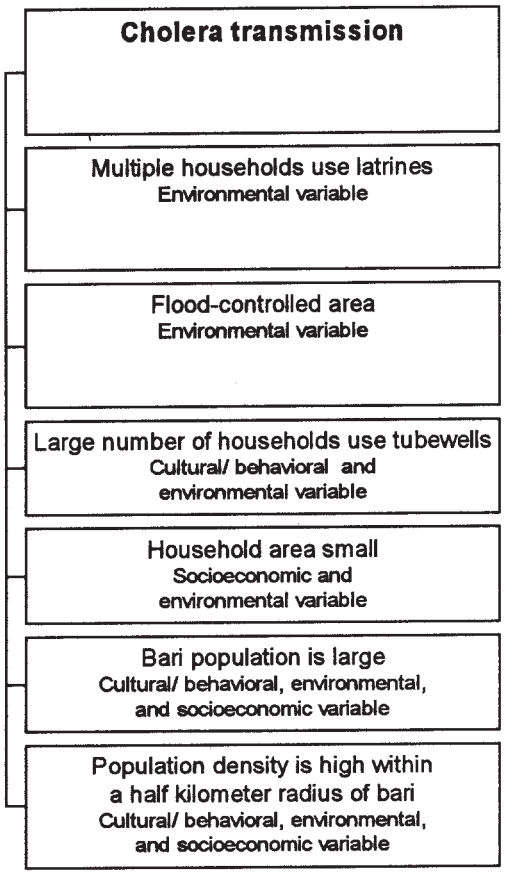

Figure 3 Variables involved in cholera transmission.

living in a bari, the population density near a bari, and the size of a housing structure. All of these have to do with the environmental circumstances in which people are living. Several of these variables show that people living in crowded areas get cholera more often.

The last variable related to cholera transmission is flood control, another environmental variable. People living inside a flood-controlled area are living in an environment that has been significantly altered by humans. This alteration certainly changes the way people interact with their environment in these areas. For example, the agricultural system in the flood-controlled area is more reliant on irrigation. It is unclear why there is an association between flood control and cholera, but it may have something to do with how people are interacting with the aquatic environment in this area.

Non-cholera transmission is exclusively secondary, via the fecal-oral route. The study area is littered with latrines that hang over water bodies that are used for bathing, washing clothes, cooking water, and occasionally for drinking water. In such a densely populated area, it is safe to say, the surface water is not fit for drinking. Figure 4 displays the factors important to non-cholera watery diarrhea transmission.

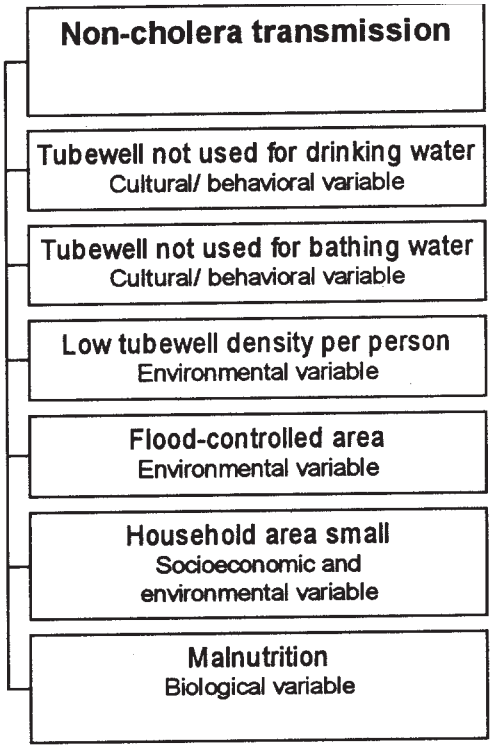

Figure 4 Variables involved in non-cholera diarrhea transmission.

Three of the variables shown in Figure 4 involve tubewell water use. Because there is no water treatment facility in the area, tubewells are the only clean source of water. Other variables associated with transmission of non-cholera watery diarrhea transmission include household area, malnutrition, and flood control. There are many types of variables that predispose people to secondary transmission of diarrhea. If clean water and sanitary latrines were used, however, then secondary transmission would be much less of a problem.

Conclusion

It is clear that sanitation and water availability and use are extremely important in the effort to reduce transmission of secondary cholera and non-cholera watery diarrhea transmission. While this may seem obvious to many outsiders, health policy makers in Bangladesh and international aid organizations continue to debate whether the appropriate tubewell coverage threshold has been achieved in rural Bangladesh. The water use and availability variables were more important for non-cholera watery diarrhea than for cholera, but they were important for both. With the exception of UNICEF, there has been very little effort to provide septic latrines to the people of rural Bangladesh even though only 10% of the study area population had concrete septic latrines. Another debate among health policy makers concerns how to increase latrine coverage.

The status quo has been that latrines are usually provided at the expense of the family or community. Because diarrhea is a poor person's disease, however, the people who need proper sanitation most are those who are least likely to be able to afford it. This research project found significant relationships between sanitation-related variables and cholera, but not between the same variables and non-cholera diarrhea. It is important to note, however, that the sanitation situation in the entire study area was very poor, so comparisons with ideal sanitation conditions could not be made.

One of the socioeconomic status indicators was related to both cholera and non-cholera watery diarrhea. The author suspects that if the study population were compared with a more affluent group, more relationships would become apparent between socioeconomic variables and the diseases. Socioeconomic status is probably the single most important indirect cause of both of diseases of concern because poverty is the root cause of many of the other variables, such as lack of sanitation and clean water. The educational level, income, assets, and living environment of the study population are abysmal. The poverty, however, will no doubt continue and these diseases will most likely continue as well. A stronger national and international policy directed at poverty alleviation in rural Bangladesh is necessary to tackle such a difficult problem. A relationship was found between malnutrition and non-cholera watery diarrhea but not for cholera. There is contradictory information in the health literature concerning the effect of malnutrition on diarrhea. It is obvious, however, that malnutrition is already a health policy concern and thus is already on the health care agenda.

Flood control was related to both types of diarrhea, but it is not understood why. Because the Bangladesh Flood Action Plan will continue to build and maintain embankments into the distant future, it is very important to investigate whether there is a pattern to this relationship throughout the country and to investigate why the relationship exists. This will no doubt require a multi-disciplinary effort involving ecologists, hydrologists, engineers, epidemiologists, and medical geographers.

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